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Data Article

High-resolution bathymetric survey dataset of Yesik Lake, Kazakhstan: New insights into the morphology of the mountain water body

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ABSTRACT

This dataset provides high-resolution bathymetric data for Yesik Lake, in southeast Kazakhstan's Tien Shan Mountain range. A bathymetric survey was undertaken from September 9 to 12, 2024, using a Lowrance ELITE Ti 9 multibeam sonar placed on a small vessel.
The dataset comprises a digital elevation model (DEM) of the lakebed with a resolution of 1 meter, together with supplementary metadata.
The supplied data facilitates comprehensive mapping of the lake's underwater topography, encompassing details on the substrate's depths, gradients, and morphological characteristics. This dataset applies to diverse research in limnology, hydrology, geomorphology, and the ecology of alpine water bodies.
The data provides a crucial basis for examining sedimentation processes, evaluating water resources, and modeling the ecosystem of Yesik Lake.

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Specifications Table

Subject	Hydrology and digital elevation model
Specific subject area	The study focuses on bathymetric surveying and mapping of lake Yesik using advanced sonar technology. The research involves detailed depth measurements conducted via a watercraft equipped with an echo sounder-chartplotter.
Type of data	Geospatial: raster layer of the digital elevation model of Lake Yesik; Tables; figures
Data format	Raw, Analysed
Data collection	A bathymetric survey of Lake Yesik was performed using an echo sounder-chartplotter from Lowrance ELITE Ti 9. The bathymetric survey was carried out on a watercraft by 2 specialists and 1 driver. The values were simultaneously recorded on an electronic medium and written down in a field diary. By agreement with the working group, as well as experience in similar work, the parameters for laying tacks at the research site were determined. The tack grid was made in the form of a Z with an internal angle of 25–45 degrees, the speed of the boat was 5 km/h, and the frequency of recording values in a time interval of every 2 s. Before performing the work, the echo sounder sensor was installed according to the manufacturer's regulations.
Data source location	Lake Yesik, Kazakhstan
Data accessibility	Repository name: Mendeley Data Data identification number: https://data.mendeley.com/datasets/d26wht4zyr/3

1. Value of the Data

- This dataset [1] is the first high-resolution bathymetric investigation of Yesik Lake and provides unique insights into the topography of the bottom of this significant mountain water body in Kazakhstan.
- A comprehensive examination of underwater relief is necessary to comprehend the hydrological processes, sedimentation, and lake ecology, a task that the dataset enables researchers to accomplish.
- The high resolution of the digital elevation model (up to one meter) allows scientists to discover tiny bottom features related to human activities or geological processes.
- The data may be used to create exact hydrological models of the lake, making it easier to manage water resources and predict water level fluctuations.
- Using this data to perform a comparative study with other alpine lakes, researchers may investigate the influence of climate change on Tien Shan water bodies and develop local conservation policies.

2. Background

The accessibility of lake bathymetry maps is essential for assessing lake water quantities and their fluctuations, which serve as a sensitive indication of climate change. Acquiring bathymetric measurements from the myriads of lakes worldwide is challenging, if not unfeasible, due to the expensive labor and/ or inhospitable topographical conditions. The in-situ mapping of lake bathymetry is costly and labor-intensive. Furthermore, owing to water's significant absorption of electromagnetic waves, large lake bathymetry cannot be directly obtained using satellite remote sensing. Consequently, bathymetric maps for most lakes globally remain unavailable [2].

Yesik Lake, located in the Tien Shan mountains in southeastern Kazakhstan, is an important natural and water management item in the region. This is a picturesque, high-mountain lake surrounded by the beautiful nature of dense forests and wide flower fields. The lake is located in the Yesik (Esik) Gorge of the Ile (Zailiyskiy) Alatau, approximately 70 km east of the city of Almaty [3]. Around Lake Esik there is a belt of spruce-deciduous forests. Large areas of forest plantations of pine, birch, and spruce create a unique attractive mountain-forest cultural landscape against the background of natural spruce forests, the highest and very steep mountains, rocks, and a stormy river flowing in a huge gorge. Tree cover consists of birch and aspen spruce forests, rowan and willow spruce forests, meadow spruce forests, juniper, and rocky spruce forests grow on the mountain slopes, among them here and there pine and birch crops - and all this against the backdrop of mountain peaks and glaciers. Above the lake, you can see the winding floodplain of the river and steep mountain slopes covered with stony moss-grass spruce forests. The belt of spruce forests in this gorge rises high, up to 2800–2900 m above sea level. There are no roads above the lake, and some paths are so dangerous for travel that only experienced mountaineers and glaciologists, observing the water level in moraine high-mountain lakes, climb them to the glaciers. The beautiful Yesik Lake, originally called Zhasyl-Kol (Green Lake), existed in its pristine beauty until 1963. In July of that year, a powerful mudflow, caused by the melting of glaciers in the upper reaches of the Yesik (Issyk) river, burst out of the glacial zone with the force of nature. Huge waves of the flow destroyed the natural dam, emptying the lake in just four hours. At present, the lake has been successfully restored, but its size has decreased by half compared to its previous size [4].

Notwithstanding its importance, comprehensive and current data on the lake's bathymetry has been absent until this point. The most recent bathymetric investigations of the lake were performed in the 1980s utilizing obsolete techniques that failed to deliver an accurate and comprehensive representation of underwater morphology. Moreover, sporadic debris flows deposit sediments that accumulate on the lake's bottom [5].

Due to the growing significance of Yesik Lake in regional water supply and electricity production, as well as its ecological importance, there is an urgent requirement for contemporary high-precision bathymetric surveys. Our research aimed to produce a current digital elevation model of the lake bottom with high resolution. This data is essential for evaluating water resources, examining sedimentation processes, monitoring the ecological condition of the water body, and formulating conservation strategies. Moreover, the acquired material will provide a basis for subsequent multidisciplinary research on this distinctive alpine lake.

3. Data Description

The collection comprises raster and vector data acquired during the bathymetric study of Yesik Lake. The primary data is supplied as a digital elevation model (DEM) of the lake bottom, recorded in GeoTIFF format. The raster file [1] possesses a spatial resolution of 1 meter and encompasses intricate details on depths and the topography of the lakebed.

The digital elevation model was developed using a shapefile containing point data representing depth values associated with specific coordinates. Spatial sampling algorithms were employed to generate the point shapefile. Data accuracy was guaranteed by employing sonar (Table 1) with a data collecting interval of 1–2 s.

4. Experimental Design, Materials and Methods

The study employed a methodology for collecting and processing bathymetric survey data for Yesik Lake (Fig. 1). This included planning the survey, using specialized equipment, and processing and interpreting the data to create the digital elevation model of the lake bottom.

Table 1
Technical parameters of chart plotter-sonar Lowrance ELITE Ti 9.

Feature	Specification
Sonar name	Lowrance ELITE Ti 9
Display Size	9 inches
Display Resolution	800×480 pixels
Display Type	SolarMax Plus
Operating Frequencies	Broadband - 83/200 kHz, CHIRP - Medium, High, DownScan/SideScan - 455/800 kHz
Transducer	TotalScan (83/200 kHz - 455/800 kHz)
CHIRP Support	Yes
Output Power	500 Watts for all channels
Max. Depth	CHIRP - 305 meters, DownScan Imaging - 91 meters
Input Power	10.8 - 17 vDC
Power Consumption	0.9 A
Water Resistance	IPX7
Dimensions	162.7 mm x 266.5 mm x 75.1 mm
Weight	1 kg

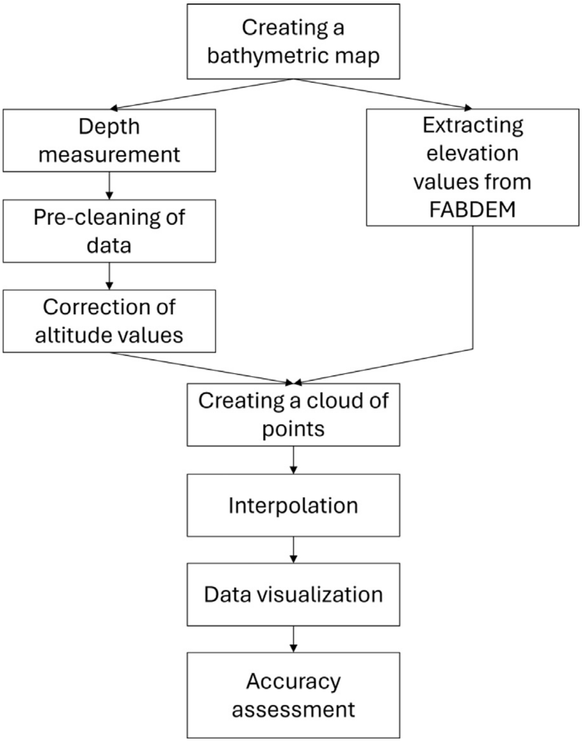

Fig. 1. Workflow of the study.

4.1. Experimental design

The investigation was intended to encompass the entire water surface of Yesik Lake. The survey was conducted along predetermined transects with a uniform spacing of 50 meters between each. This method eliminated data gaps [6] and ensured uniform coverage of the lake body. The routes guaranteed coverage of both coastal and profundal areas of the lake.

4.2. Materials

The bathymetric survey was conducted utilizing the subsequent instruments and resources:

- A gasoline engine-powered inflatable PVC boat facilitates lake crossings.
- Depth data collection was conducted using a Lowrance ELITE Ti 9 chart plotter-sonar. The sonar collected data with a 1–2 s measurement frequency, hence permitting considerable data density about depth.
- A GPS receiver integrated within the sonar attains precision of up to two meters, supported by precise documentation of each measurement point's location.
- ArcGIS 10.8 for visualizing, data processing, and analysis.

5. Methods

A bathymetric survey of Yesik Lake was conducted using a Lowrance ELITE Ti 9 sonar placed on a gasoline-powered rubber boat. Fieldwork occurred from September 9 to December 12, 2024. The sonar logged depths every one to two seconds. Each measurement point's accurate location was identified using an inbuilt GPS receiver, hence assuring perfect spatial data alignment (up to two meters). To give consistent coverage of the entire aquatic area, the ship negotiated at a speed of 3–4 km/h over predefined transects separated by 50 meters.

Preliminary data cleaning. Initial data purification was conducted to eliminate noise and inaccuracies induced by external factors like weather and wave activity [7]. The data cleansing ensured uniform results for the subsequent interpolation and improved the measurement quality.

Creation of Point Cloud. Fig. 1 depicts the methodology for generating a point cloud from the sanitized data. Coordinates and depth data were accessible for each location, so augmenting further study. The data structure excelled in supplementary spatial processing and analysis [8]. The sonar data were consolidated into a singular shapefile for subsequent processing. This technology enabled the application of analytical tools and visualization methods by guaranteeing data integrity and accelerating data processing.

Elevation data were obtained from 300 randomly selected regions adjacent to Yesik Lake with the FABDEM digital elevation model (Forest And Buildings removed Copernicus 30 m DEM) [9]. These sites were selected to guarantee sample representativeness and to illustrate diverse regions of the area. This method enhanced data reliability and facilitated superior geographical analysis.

After data cleaning and point cloud creation, all processed data were combined into a single shapefile. This process ensured data integrity and readiness for subsequent analysis. The integration of data allowed for the creation of a unified database for an in-depth study of the morphological features of Yesik Lake (Fig. 2).

Correction of Elevation Values. After the first data purification and point cloud creation, depth measurements were rectified. The Baltic height system lets one translate heights to absolute values. To get accurate and comparable data, the sonar's depth readings were subtracted from the average water surface level of Yesik Lake. This change guaranteed the necessary accuracy for further models and research. The acquired data was merged into one shapefile to ensure its integrity and structure for next use. This approach made it feasible to build a single database from which additional phases of research and in-depth analysis could proceed.

Interpolation Using Kriging. Designed for spatial data analysis, the digital elevation model of the lake bottom was created by Kriging interpolation.

$$Z(x) = \sum_{i=1}^{N} \lambda_i Z(x_i)$$

Where:

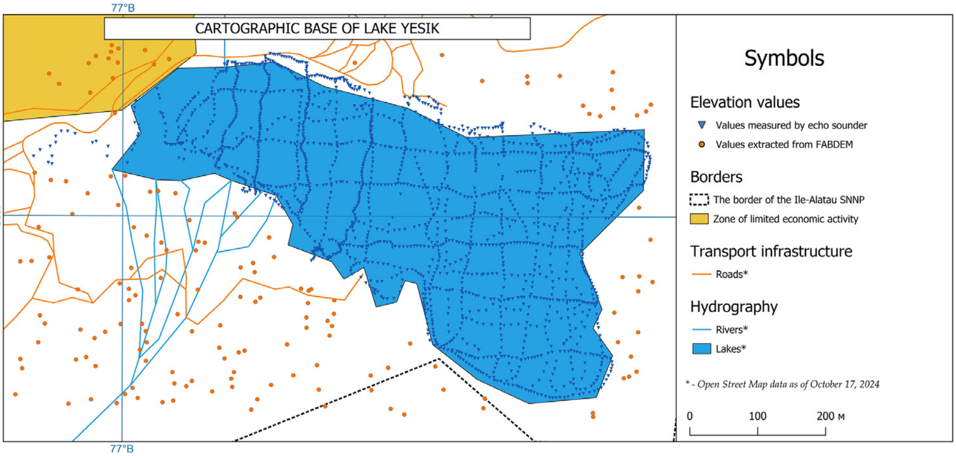

Fig. 2. Combined data for the analysis of the bottom relief of Lake Yesik.

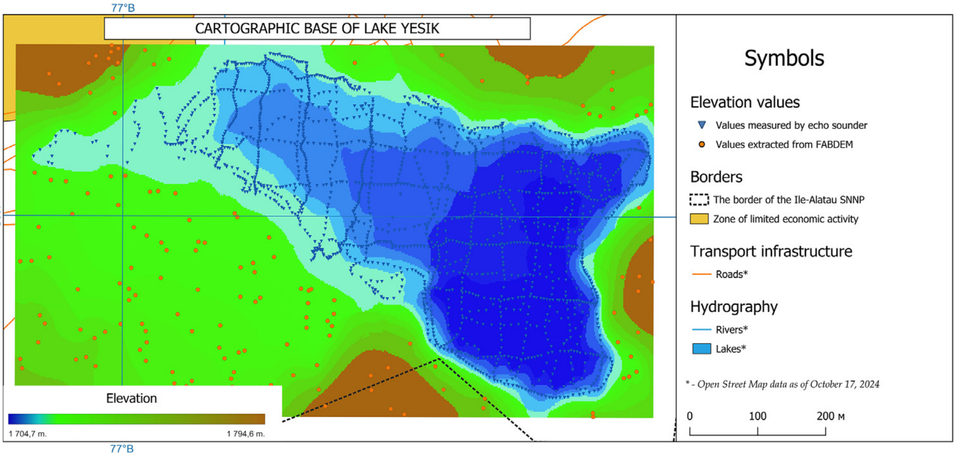

Fig. 3. The relief of the bottom of Lake Yesik.

- $Z(x)$ – predicted value at the point x
- N – number of observed points
- λ_i – values depending on the distance and correlation between points
- $Z(x_i)$ – observed value at point x_i

The technique minimizes the variance of prediction errors by considering the spatial correlations between sites. For building accurate elevation models [10], interpolation using Kriging offers the best linear unbiased prediction of intermediate values, hence it is ideal.

Data Visualization. The data were combined into a digital elevation model and displayed with ArcGIS 10.8 following interpolation. A 3D model of the lake bottom was produced using the Spatial Analyst module, which allowed the thorough depiction of morphological elements like slopes and submerged structures. Digital elevation models (DEMs), slopes, and aspects were computed, and high-precision lake terrain visualization was produced using the 3D Analyst Toolkit's capabilities.

Accuracy Analysis and Error Assessment. The data were combined into a digital elevation model and rendered with ArcGIS 10.8 following interpolation (Fig. 3). A 3D model of the lake bottom was produced using the Spatial Analyst module so that morphological elements including slopes and submerged constructions could be precisely shown. In addition, the 3D Analyst Toolbox's features helped to create digital elevation models (DEMs), slope and aspect computation, and very precise lake terrain visualization.

Limitations

Though its remarkable resolution and precision, using the bathymetric data for Yesik Lake has significant limitations that should be considered:

- Seasonality: September was the survey month; hence water levels might have fluctuated seasonally. Particularly in coastal areas, changes in water level could affect the relief of the lakebed [11].
- Coastal Zone: Data for such sites may be less accurate or nonexistent due to the small vessel's limited access to shallow waters (less than one meter deep).
- Temporal Resolution: Here the lake bottom relief is a one-time "snapshot" free of dynamic change across time.
- Coverage: Technical limitations or bad weather could have forced the survey to cover some hard-to-reach areas of the lake, especially on the northern side, insufficiently.
- Interpolation: Data interpolation was used in sites with sparse measurement grids, therefore perhaps reducing model accuracy in some places.

These constraints should be considered while planning the next research and evaluating the data obtained.

Ethics Statement

The authors confirm that they have familiarized themselves with the ethical requirements for publication in the journal Data in Brief and adhere to them. This work does not involve research involving human participants, animal experiments, or data collection from social media.

The data collection on Yesik Lake was conducted following the national legislation of the Republic of Kazakhstan.

The study was carried out with minimal impact on the lake's ecosystem. The methods used for data collection did not compromise the integrity of the aquatic environment and posed no threat to the flora and fauna of the water body.

CRediT Author Statement

Kanat Samarkhanov: Methodology, Data curation; **Nurlybek Zinabdin:** Methodology, Formal analysis; **Damir Amantayev:** Data analysis, Validation; **Arman Kabdeshev:** Research planning, Data collection, Validation; **Murat Muzdybaev:** Data collection; **Aigerim Amantai:** Data curation, Visualization; **Kairat Abdrakhmanov:** Formal analysis, Validation; **Aigerim Nurmagambetova:** Data description; **Alua Zhukenova:** Dataset description; **Aliya Kaisanova:** Literature review.

Data Availability

High-resolution bathymetric dataset of Lake Issyk, Kazakhstan: new insights into the morphology of a mountain reservoir (Original data) (Mendeley Data).

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Declaration of Competing Interest

The authors declare that there are no known competing financial interests or personal relationships that could have influenced the work presented in this article.

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